

## ***Evaluation of Lubricating Properties of Oils on The UMT Series Micro-Tribometer***

**Summary:** The tribological properties of two different oils, basic oil A and Teflon-enhanced oil B, were evaluated utilizing the CETR UMT-Series Micro-Tribometer. The Stribeck curve at variable sliding speeds (from 0.2 to 1000 mm/min) and loads (from 1 to 30 N) was obtained. Oil B demonstrated lower friction and better lubricating properties than oil A. Both oils showed a stick-slip phenomenon at low speeds and high loads. An increase in temperature from 25° C to 140° C caused a reduction in friction for both oils, but this reduction was more significant for oil A.

**Instrumentation:** The friction forces and coefficient of friction of the oils were evaluated utilizing a UMT Micro-Tribometer. This precision instrument is used for tribological studies of solid lubricants, lubricating fluids, oils and greases, thin and thick coatings, ceramics, plastics, and metals. The following parameters can be measured:

- 1 - Friction force and coefficient,
- 2 - Adhesion force,
- 3 - Wear (including fatigue, abrasive and adhesive wear),
- 4 - Contact resistance or capacitance,
- 5 - Temperature in the friction zone,
- 6 - Acoustic emission.

The micro-tribometer can accommodate both upper and lower specimens of a wide variety of shapes and dimensions. The upper specimen is connected to a vertical linear motion system that travels with a resolution of 1  $\mu$ m (optional 50 nm). Reciprocating mode can be achieved in both vertical and horizontal directions. The lower specimen is fixed on a rotating table that has velocity range from 0.001 rpm up to 5000 rpm (the rotation is used for positioning and/or tribological measurements). The ultra-accurate strain-gauge sensor performs simultaneous measurements of the normal load and friction force (torque) with very high resolution and repeatability. The normal load sensor provides

feedback to the vertical motion controller, actively adjusting the upper specimen position to control the load during testing. The heating chamber provides a temperature range from ambient to 150°C (optional 200°C). The tester has a fully automated PC-based motor control and data acquisition, with a user-friendly software interface in a Windows-95 multitasking environment.

1. **The coefficient of friction at variable speeds and loads, at ambient temperature.**

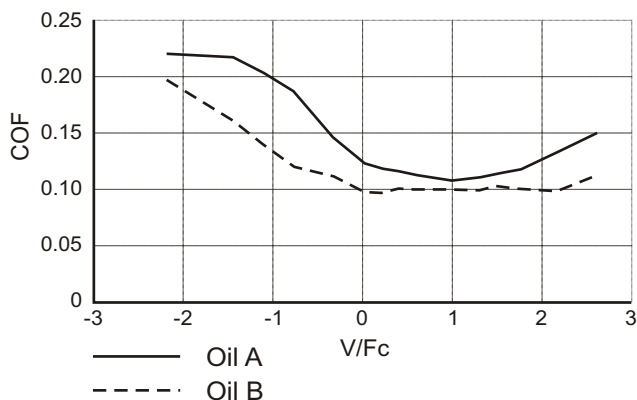
**Experimental procedure:** A flat round plate (steel 52100, HRC 20), as the lower specimen, was fixed on the tribometer stage. A thin layer of oil (drop of 0.05 ml) was put on the lower specimen. The upper specimen was a ball (steel 52100, HRC 60) with a radius of 0.75 mm. It was brought in contact with the lower specimen and lubricant. Then, the upper specimen rotation was started. First, a running-in was conducted for 3 min at 300 mm/min. Then, a friction test was performed, per the test script (Table 1). During the test, both the sliding speed and load varied as follows: the sliding speed (V) decreased from 1000 mm/min to 0.2 mm/min, and the load (Fz) increased from 1 N to 30 N. By such variation of the speed and load, the V/P ratio was raised from 0.01 to 1000. The variable time duration was chosen for different speeds, to keep the constant sliding distance of 150 mm.

The torque, friction forces and normal load were monitored and stored in the computer. The coefficient of friction COF was reported. The wear track width was measured with an optical microscope and was found to be about 0.15 mm.

**Results :** The results of the test for both oils are presented in Table 1 and Figure 1. At low V/Fz ratio (see left part of Figure 1) the coefficient of friction was high (0.2), which corresponded to the boundary lubrication. With an increase in

the  $V/Fz$  ratio, the coefficient of friction dropped for both oils by a factor of 2 to the minimum value of 0.1 where the hydrodynamic film was formed. With a further increase of the  $V/Fz$  ratio (see right part of Figure 1), the coefficient of friction stayed low with a slight increase due to viscous internal friction in the lubricant films. Both oils demonstrated a stick-slip phenomenon at low speeds and high loads:  $V/P$  less than 1.67 (Figure 2).

Figure 1. COF versus  $V/P$  curve



performed to evaluate the changes in lubricity as a function of temperature. The micro-tribometer with a heating chamber was utilized. The test was initiated at 25 °C, then performed at 50, 100 and 140 °C at an interval of 10 minutes. All tests were done at the sliding velocity of 600 mm/min and load  $Fz$  of 4 N. The sliding distance was 6,000 mm. Table 2 presents the data. The coefficient of friction dropped by a factor of 2 for oil A, and a solid-like film was built on the steel surface after the experiment. This film could be removed with acetone. Oil B also showed a COF decrease, but less than oil A; no solid-like film was observed after the experiment.

Figure 2. The stick-slip phenomenon, oil A, speed  $V=2$  mm/min, load  $Fz = 26$  N.

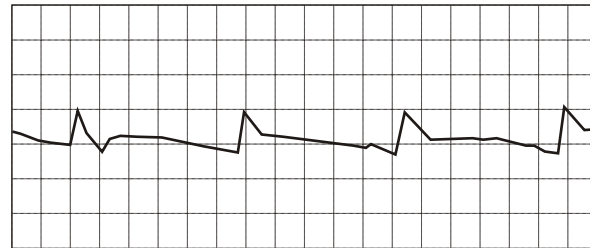


Table 1. Test script and results

Load $Fz$ , N	Speed $V$ , mm/min	Ratio $V/Fz$	Log $V/Fz$	COF, oil A	COF, oil B
1	1000	1000.000	3.00	0.15	0.11
2	800	400.000	2.60	0.15	0.11
4	600	150.000	2.18	0.14	0.10
6	300	50.000	1.70	0.11	0.10
8	240	30.000	1.48	0.12	0.10
10	200	20.000	1.30	0.11	0.10
12	100	8.333	0.92	0.11	0.10
14	50	3.517	0.55	0.12	0.10
16	40	2.500	0.40	0.12	0.10
18	30	1.667	0.22	0.12	0.10
20	20	1.000	0.00	0.12	0.10
22	10	0.455	-0.34	0.15	0.11
24	4	0.167	-0.78	0.19	0.12
26	2	0.077	-1.11	0.20	0.14
28	1	0.036	-1.45	0.22	0.16
30	0.2	0.007	-2.18	0.20	0.20

Table 2. COF versus temperature

Oil	Temperature, °C			
	25	50	100	140
A	0.14	0.09	0.086	0.072
B	0.1	0.07	0.07	0.07

## 2. The coefficient of friction at different temperatures.

**Experimental procedure:** This test was

## Conclusions

1. The Stribeck curve at variable sliding speeds and loads was obtained utilizing the CETR UMT-Series Micro-Tribometer.

2. It was found that oil B with Teflon additives had better lubricating properties than oil A. Both oils showed a stick-slip phenomenon at low speeds and high loads.

3. The coefficient of friction dropped by a factor of 2 for oil A in the temperature range from 25° C to 140 °C. Oil B also showed a COF decrease, but less than oil A.

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